Reconstruction of the patella with an autogenous iliac graft: clinical and radiologic results in thirteen patients

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Abstract

Purpose Extension lag, quadriceps weakness and subluxation of the extensor apparatus are known complications of patellectomy. In the case of total knee joint replacement with a nonconstrained system an instability may be encountered. Reconstruction of the patella allows restoration of the moment arm to improve quadriceps leverage. The goal of our study was to analyse the clinical and radiological results after reconstruction of the patella with an autogenous iliac graft.

Methods 13 previously patellectomized patients had reconstruction of the patella with an autogenous iliac graft and were retrospectively studied by clinical and radiographic examination. For evaluation we used the scores of Feller and the Knee Society. Also, all complications were recorded.

Results After an average follow-up of 40.1 months, nine patients had full strength of the quadriceps, while six had an improved function of the extensor apparatus. The mean Feller score was 21.8 and the Knee Society score was 67.3 for knee and 57.5 for function. Six complications occurred including three infections, two problems with the replaced patella and one fracture of the anterior superior iliac spine.

Conclusions Reconstruction of the patella with an autogenous iliac graft enables the strength of the extensor apparatus with restoration of the knee joint.

Introduction

Excision of the patella is sometimes indicated in intractable pain from patellofemoral arthrosis and chondromalacia or following severe comminution from fracture [1]. But extension lag and quadriceps weakness are known complications of a patellectomy [2]. In addition, a subluxation of the extensor apparatus may be present. Should a total joint replacement become necessary after patellectomy, an instability may be encountered if a nonconstrained system is used [3]. The reconstruction of the patella allows restoration of the moment arm to improve quadriceps leverage as well as a patellar resurfacing.

Several methods have been described for total and partial patella reconstruction using autogenous and allogenic bone [2, 4–11]. In this series we used a modified technique of the reconstruction of the patella with an autogenous iliac crest graft first described in detail by Buechel; thus, the goal of our retrospective study was to analyse the clinical and radiological results and to show the complications after this special surgical method [2].

Patients and methods

During a period of 8.5 years one male and 12 female patients had been operated in our clinic. Their average age was 59.9 years (range 33.8–82.0 years). The mean duration of follow-up was 40.1 months (range 3.0–92.0 months). The reasons for patellectomy were the following: comminuted fractures in six cases, recurrent patellar subluxation in two, retropatellar arthrosis in two, reconstruction of a tibial fracture in one, knee joint infection in one, and chronic pain after total knee arthroplasty (TKA) in one. The main indications for reconstruction of the patella in these patients

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were instability (four), extension lag (two), instability and pain after TKA (one), instability after TKA (two), extension lag and pain after TKA (one), extension lag after TKA (one), instability and pain (one), and pain (one). Nine of the 13 patients had concomitant operations during the patellar reconstruction procedure, which were TKA in six cases, arthrolysis in one, change of femoral component of TKA in one, and revision of pseudarthrosis after periprosthetic fracture in one patient. The average age at the time of patellectomy was 43.4 years (range 28.0–68.0 years) and the mean time from patellectomy to patellar reconstruction 16.5 years (range 1.6–36.4 years).

The operative technique used in our patients was previously described in detail by Rudert et al. and is a modification of the reconstruction of the patella with an autogenous iliac crest first published by Buechel [2, 12]. Contrary to Buechel's technique, we turned the graft by 90°. In case of simultaneous indication for TKA, the patellar reconstruction procedure was performed after finishing the implantation of the prosthetic components. The postoperative treatment was continued without any limitations of knee joint movement and with full weight bearing.

All patient charts were intensively searched for any kind of complication or adverse effect. At final follow-up examination, several parameters were documented and, if possible, compared to the preoperative situation (Table 1). The Feller score was used which was specifically developed to classify patellar problems [13]. Furthermore, the score of the Knee Society was used to analyse the knee rating and the functional assessment separately with 200 points together as maximum score [14]. Finally, the patients were asked if they were satisfied with the operation.

For radiographic evaluation, the patellar height was measured according to the method of Blackburne and Peel on lateral roentgenograms of the knee, indicating a normal patella height between 0.70 and 0.99 (Blackburne-Peel-Index) [15]. The second parameter to classify the position of the patella was measuring the patellar tilt in the technique of Merchant on a tangential view of the patellofemoral joint [16]. Normal values are between -6° and 16° . In addition, the thickness of the “new” patella was measured on tangential X-rays directly after operation and at follow-up.

Statistical analysis

To find out any statistically significant differences between the values of the functional scores at follow-up in the satisfied and dissatisfied patient groups, two-sided *t*-test was used. A *p*-value of <0.05 was considered significant.

Results

The clinical follow-up data were available for 12 of the 13 patients, because in one patient the patellar substitute had to be removed one month after operation due to infection. However, for radiological evaluation the directly postoperative X-rays of this patient were taken for analysis.

The relevant data about the clinical findings before operation and at follow-up and the scores according to Feller and the Knee Society at follow-up are shown in Table 1. Regarding the function of the extensor apparatus, half of all patients ($n=6$) had some improvement of the quadriceps strength and nine patients demonstrated full strength of this muscle (Medical Research Council, MRC grade 5/5) at follow-up. One woman even showed increase of her quadriceps strength from grade 1/5 to grade 4/5. Seven of the 12 controlled patients were satisfied with the result of the operation.

The Blackburne-Peel index at follow-up showed an average value of 0.84 (range 0.30–1.57). The mean patellar tilt in the technique of Merchant was 3.7° (range -34.0° to 78.0°). The mean thickness of the “new” patella at follow-up was 17.2 mm (range 5.0–25.0 mm), whereas directly after operation it was at an average 4.2 mm higher (19.6% decrease).

Six patients were affected by complications. Three patients had infectious problems with one infection of the patella itself with *Enterococcus faecalis*, which had to be removed one month after primary operation. One patient had numerous infections of the TKA (*Staphylococcus aureus*) with several removals and re-implantations. The third person had an isolated wound infection with *Staphylococcus epidermidis* and *Acinetobacter baumannii* which was cured by debridement and secondary wound closure. In another patient the patella was positioned too far laterally during operation which led to pain when going down stairs and instability with 'giving way' phenomenon. This woman had a second surgical procedure with transposition of the patella to the medial side. In one patient the X-rays showed ossifications laterally of the TKA. They were removed together with adhesiolysis and synovectomy. The last patient had an avulsion fracture of the anterior superior iliac spine, and the bony fragment was refixed by screws. Two other patients showed signs of loosening of the TKA in roentgenograms at follow-up and had been advised to have further investigations (szintigraphy), but these problems were certainly not related to the patella reconstruction procedure itself.

Clinical case

A 72-year-old woman had undergone TKA nine years previous. Five years later, she had a traumatic patella

Table 1 Clinical data before operation and at follow-up and scores at follow-up in 12 patients

Parameter	Preoperatively	Follow-up	Difference (%)
tROM [°]	88.5	97.5	+9.0 (+9.2)
Permanent pain (<i>n</i>)	10	4	
Incidental pain (<i>n</i>)	1	5	
No pain (<i>n</i>)	1	3	
Extension lag (<i>n</i>)	5	3	
Mean quadriceps strength (MRC grades, 0=complete paresis, 5=full strength)	3.9	4.7	+0.8 (+17.0)
Subjective knee instability (<i>n</i>)	8	3	
Objective knee instability (<i>n</i>)	2	1	
Swelling (<i>n</i>)	6	4	
Pain iliac crest (<i>n</i>)	-	1	

Measurement method	Average points (standard deviation)	Minimum	Maximum
Feller score (maximum score of 30)	21.8 (6.1)	12	30
Knee Society score			
Knee (maximum score of 100)	67.3 (25.6)	14	99
Function (maximum score of 100)	57.5 (20.3)	35	100

fracture with subluxation to the lateral side and she developed a necrosis of the patella, so that a patellectomy was performed (Fig. 1a). After this procedure, she suffered from instability of the knee with 'giving way' phenomenon. At clinical examination, she had an extension lag with free passive ROM. Therefore, patellar reconstruction with an autogenous iliac graft was performed without any complications (Fig. 1b, c). At follow-up, the patient was free of pain and very satisfied with the result of the operation. She had a flexion of 120° and full extension without any subjective and objective signs of ligamentous instability. The value of the Feller score was 27 points. The score of the Knee Society was 99 for knee and 45 for function.

Discussion

Indications for replacement of the patella are problems after patellectomy with extension lag, quadriceps weakness and subluxation of the extensor apparatus [2]. If TKA becomes necessary after patellectomy, the patients are at high risk of instability if a nonconstrained system is used [3]. Moreover, patellectomized patients undergoing TKA have less predictable results with lower postoperative clinical scores [3, 17–21]. In contrast, there are also reports about good or excellent results in TKA after previous patellectomy without reconstruction of the patella [20, 22]. Therefore, during assessment for TKA, it has to be decided individually if a substitution of the patella is really necessary, particularly in patients without any problems after patellectomy who

often do not need patellar reconstruction at all. Another reason for patella reconstruction is a planned patellar resurfacing after or during TKA. Contraindications are soft tissue defects at the anterior aspect of the knee, complete ruptures of the extensor apparatus, and paresis of the quadriceps muscle.

The surgical principles and objective of the described technique are replacement of the excised patella with an autogenous iliac bone graft for improvement of the leverage arm of the extensors mechanism and thus improvement of joint function. Also, a tendency to subluxation of the scarred extensor apparatus is prevented, and a bony bed for a later patellar resurfacing is created. The obvious disadvantage of this technique is the need for harvesting of bone graft from the iliac crest with its potential risks (hematoma, infection, fracture, prolonged pain). Buechel was the first author who published a special technique for complete patellar tendon bone grafting [2]. He used an autogenous bone block from the iliac crest, which was shaped into a 2.5 cm diameter circle or ovoid with trimming to fit the femoral groove of the femoral component by developing medial and lateral facets if possible. The difference from our technique was a turn of the graft by 90°. This original method was performed in six patients (seven knees) with primary or revision TKA. According to Buechel's own evaluation system for the rating of knee function, he classified the outcome at follow-up in four knees as excellent, in two as good and in one as fair [23] (Table 2). In the literature we found some alternative techniques for total and partial patellar reconstruction (Table 2). To the authors' knowledge, the

Fig. 1 **a** Lateral radiograph of a 72-year-old woman with TKA; state after patellectomy. **b** Lateral radiograph. Three months after patellar replacement with an autogenous bone graft harvested from the iliac crest. **c** Tangential radiograph. Central position of the “new” patella three months after operation

presented study deals with the biggest case series ever published about patients with total patellar reconstruction after previous patellectomy. The patella was always replaced by an autogenous iliac graft. The reconstructive operation was performed in two patients without an additional procedure, in six cases during simultaneous primary TKA, and five patients already had got previous TKA. A secondary patellar resurfacing did not become necessary in any patient.

The clinical outcome showed good results (Table 1). The total ROM was increased by 9%. Before the operation, ten of the 12 clinically evaluated patients suffered from permanent and one patient from incidental knee pain; only one person had been completely free of pain. At follow-up, three patients were without any pain and five patients had

only incidental painful knees. The four patients with persistent knee pain also had permanent pain preoperatively, and further details of their other clinical and radiological findings are presented in Table 3 (patients 1–4). These four patients had almost always fewer points in their scores than the average. Two of these patients had a persistent extension lag and slight quadriceps weakness. Only one woman showed clear limitation in her ROM, and another patient had knee instability. These four chronic pain patients were all not satisfied with the result of the patellar reconstructive operation, including two patients who had not had any postoperative complication with revision surgery. Independent of these two operation-related problems, one patient had a concomitant depression and two patients showed signs of TKA loosening at follow-up, which would be an explanation for having persistent complaints as well as for the dissatisfaction. The fifth person (Table 3, number 5), who was not satisfied with the overall operative result, indeed had had a complication and revision surgery, but the clinical findings at follow-up were good with only slight and incidental knee pain, an unlimited ROM, full quadriceps strength and without any signs of instability. The Feller score was 20 points, and the Knee Society score for knee was 95 and for function 45. In conclusion, a trend between the clinical follow-up data and the subjective outcome assessment could be observed in the dissatisfied patient group, but not a clear correlation. Concerning the radiographic analysis, all five unhappy patients had no “normal” patellar height, according to the measuring method to Blackburne and Peel [15]. However, the patellar tilt was physiologic in three of the five cases.

Regarding the seven satisfied patients, their clinical and radiographic data are presented in Table 4. The total ROM was between 65° and 130°, and only one patient showed an extension leg due to a slightly decreased quadriceps strength (grade 4/5). No patient had signs of knee joint instability. The mean values of the Feller score were definitely higher than in the dissatisfied patients with 25.4 points in the satisfied group versus 16.8 points in the unhappy collective, which was statistically significantly different ($p=0.007$). The same trend was seen in the score of the Knee Society with average values of 79.7/66.4 points for knee and function in the satisfied persons in contrast to 49.8/45.0 points in the unsatisfied group (statistically significant difference in score for knee with $p=0.038$, not significantly different in score for function with $p=0.067$). Only four patients had incidental knee pain episodes, while three persons were completely free of pain. The iliac crest was not painful at all. Two of the seven patients had a complication with the need for revision surgery but without a long-term negative effect of the overall outcome. In summary, positive clinical findings and higher scores seem

Table 2 Review of the literature about alternative techniques for total and partial patellar reconstruction

Author	Material for patellar reconstruction	Number of patients/knees	Clinical outcome	Radiographic findings or thickness of patella post-OP/follow-up (mm)	Complications
Buechel [2]	Autogenous iliac crest	6/7	4 excellent, 2 good, 1 fair	16.8/12.8 (–23.8%)	2 revisions
Jabbar and Ruiz [6]	Autogenous posterior lateral femoral condyle	1/1	Positive	No resorption	No
Pang and Sathappan [9]	Distal femoral autograft	1/1	Excellent	Established graft viability	No
Lakshmanan and Wilson [8]	Autogenous tibial plateau	1/1	Excellent	Incorporation of well-positioned bone graft in patella tendon	No
Tirveilliot et al. [11]	Autogenous tibial plateau (6), homologous femoral head (1), additionally cemented polyethylene button (5)	7/7	Clear improvement directly post-OP	4 progressive migrations	4 graft removals due to failure of fixation leading to progressive migration
Hanssen [5]	Autogenous cancellous bone from metaphyseal femur or cancellous allograft into patellar bone defect	8/9	Significant improvement	22.0/19.7 (–10.5%)	1 arthrofibrosis, 1 migration of femoral component of TKA
Tabutin [10]	Autogenous monocortical iliac crest, additionally cemented patellar button	2/2	Positive	2 bone-cement lucency	No
Bakay et al. [24, 25]	Mushroom-shaped patella allograft	8/8	2 excellent, 4 good, 2 fair	1 fragmentation	1 graft failure
Emerson et al. [4]	Allogenic quadriceps tendon-patellar-patellar tendon-tibial bone block	4/4	Not exactly described for patellectomized patients	Not exactly described for patellectomized patients	Not exactly described for patellectomized patients
Kulkarni et al. [7]	Allogenic quadriceps tendon-patellar-patellar tendon-tibial bone block	1/1	Satisfied with operation	Normal patella height	No
Busfield and Ries [26]	Allogenic quadriceps tendon-patellar-patellar tendon-tibial bone block	7/9	6 improvement	24.0/15.0 (–37.5%), 1 lateral tilt, 2 partial resorptions	2 amputations due to infection, 1 revision because of fragmentation
Own study	Autogenous iliac crest	13/13	7 satisfied, 5 dissatisfied, Feller score 21.8, Knee Society scores 67.3/57.5	21.4/17.2 (–19.6%), mean Blackburne-Peel-Index 0.84, mean patellar tilt 3.7	3 infections, 1 malposition, 1 ossification, 1 fracture

Table 3 Clinical and radiographic findings at follow-up in the four patients with persistent knee pain (numbers 1–4) and dissatisfaction at follow-up and one patient was also not satisfied with the operation result (number 5)

Patient number	ROM (E/F) [°]	Extension lag	Quadriceps (MRC grade)	Instability	Feller score	Knee Society score: knee	Knee Society score: function	Pain iliac crest	Satisfied with operation	Complications	Revision surgery	Comment	Blackburne–Peel index	Patellar tilt of Merchant
1	0/40/85	Yes	4/5	No	23	14	45	No	No	No	No	Depression, chronic pain patient	1.52	78
2	0/0/125	No	5/5	Yes	13	55	35	No	No	No	No	TKA loosening	0.59	54
3	0/0/90	No	5/5	No	12	45	55	No	No	Lateral ossifications	Removal of lateral ossifications, adhesiolysis, synovectomy	-	0.43	0
4	0/0/100	Yes	4/5	No	16	40	45	Yes	No	Wound infection	Debridement, secondary wound closure	Suspicion of TKA loosening	1.57	0
5	5/0/130	No	5/5	No	20	95	45	No	No	Patellar graft too far lateral	Patella transposition to medial side	-	1.13	0
Mean					16.8	49.8	45.0						1.05	26.4

ROM range of motion, E/F extension/flexion

Table 4 Clinical and radiographic findings at follow-up in the seven satisfied patients (numbers 6–12)

Patient number	ROM (E/F) [°]	Extension lag	Quadriceps (MRC grade)	Instability	Feller score	Knee Society score: knee	Knee Society score: function	Knee pain	Pain iliac crest	Complications	Revision surgery	Blackburne–Peel-Index	Patellar tilt of Merchant
6	5/0/125	No	5/5	No	20	85	80	Incidental	No	No	No	0.68	-24
7	0/0/90	No	5/5	No	30	73	80	Incidental	No	No	No	0.83	-34
8	0/5/70	No	5/5	No	30	68	100	no	No	Numerous TKA infection	Revision TKA (removal, re-implantation)	0.38	0
9	0/0/70	No	5/5	No	22	59	35	Incidental	No	No	No	1.38	-22
10	0/0/120	No	5/5	No	27	99	45	No	No	No	No	0.30	0
11	0/0/90	No	5/5	No	22	88	65	Incidental	No	No	No	0.62	22
12	0/0/110	Yes	4/5	No	27	86	60	No	No	Avulsion fracture of anterior superior iliac spine	Refixation with screw	0.50	0
Mean					25.4	79.7	66.4					0.67	-8.3

ROM range of motion, E/F extension/flexion

to have a positive influence on the patients' self-assessment. When looking at the radiographic measurement of the patella height, only one patient had a position of the patella in a physiologic range. The patellar tilt was normal only in three patients. When interpreting the radiographic results, we can assess that there is no correlation between the clinical and radiological findings at all, neither in the satisfied nor in the dissatisfied patient group. The development of the quadriceps strength after patellar reconstruction was very positive and showed good overall improvement. At follow-up, half of all patients demonstrated increasing in the strength of their extensor apparatus with nine persons showing full muscle strength. No patient had a grade lower than 4/5 at follow-up. The biggest difference was improvement from grade 1/5 before operation to grade 4/5 after patella reconstruction.

Our results confirm the hypothesis that reconstruction of the patella can be a very effective procedure to restore strength of the extensor apparatus and that it could be indicated in patients after patellectomy with extension lag due to quadriceps weakness. Furthermore, patellar replacement can reduce subjective and objective instability of the knee joint and decrease the incidence and intensity of pain in most patients.

When interpreting the clinical and radiological parameters like ROM, muscle strength, and radiographic scores, we have to be aware that these measurements are not clearly objective and dependent on the investigator itself with restrictions because of the well-known limitations due to intra- and interobserver variation.

The complication rate seems to be relatively high with six of 13 patients having been affected by any problem (46.2%). Three infections had occurred with one requiring removal of the patella graft one month later. The other two patients were cured by several revision surgeries. But infectious problems are not uncommon in knee surgery, especially in TKA, and have to be seen in that context. The three affected patients had no uniform microbiological pattern with four different types of bacteria. None of the three patients had the patellar reconstruction alone. Two women had also got TKA, whereas one of them had several knee operations in the past, which already resulted in previous infections. The third patient had patellar reconstruction simultaneous to revision of a pseudarthrosis of a periprosthetic fracture of the knee prosthesis. Regarding these three cases, each patient had a complex surgical procedure and therefore was certainly at high risk for any infectious problem which could explain the relatively high rate. Peri- and postoperative antibiotic treatment is strongly recommended in such conditions.

In one patient, the patellar graft had a malposition, which was a clear operation related complication. But the

problem was solved by transposition of the patella to the medial side. Also, a complication directly resulting from the bone harvesting was the avulsion fracture of the anterior superior iliac spine, which healed without problems after screw fixation. To prevent this complication, the tricortical bone graft should be removed with a minimum of three fingers distance to the anterior superior iliac spine.

According to other reports about patellar reconstruction by different techniques like autogenous or allogenic bone, all authors who mentioned data about the radiographic behavior noticed a reduction in patellar thickness after operation between 2.3 and 9.0 mm (Table 2) [2, 5, 26]. This observation is concordant with our own findings with a mean reduction of thickness of 4.2 mm. Therefore, the "new" patella should have a thickness of a minimum of 10 mm during operation. Despite these findings, the clinical outcome is not negatively affected by the partial bony resorption.

In general and concordant to the above-mentioned reports about other patellar replacement techniques, reconstruction of a "new" patella using autologous or allogenic bone material offers a valuable operative method to increase the knee function and to reduce the typical complaints in cases of previous patellectomy. A direct comparison between the different methods and materials for patellar reconstruction cannot be made, because most reports are small patient series or just case reports. Therefore, we should note that each of the techniques has its own special advantage and also one or more potential problems (for instance high failure rate by using allogenic material like quadriceps tendon-patellar-patellar tendon-tibial bone block). According to the presented results of our study, which deals with the largest number of cases ever published, the use of an autogenous iliac graft can be an effective method and most of the patients had a clear benefit regarding their knee function. However, we should be aware that the surgical technique is challenging and has a relatively high potential for complications, especially for infectious problems, because several patients need concomitant operations like TKA in the same session. Therefore, patellar reconstruction should be indicated very restrictively and only in selected patients having typical and significant problems after patellectomy. The obvious disadvantage of this technique is the need for harvesting of bone graft from the iliac crest with its potential risks. However, only one patient had an avulsion fracture of the anterior iliac spine without any negative long-term problems, and just one person suffered from iliac crest pain at final follow-up.

Conflict of interest The authors declare that they have no conflict of interest.

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